

From Royaumont to Lyon

Citation for published version (APA):

De Bock, D., & Zwaneveld, G. (2017). *From Royaumont to Lyon: Applications and Modelling During the Sixties*. Paper presented at International Conference on the Teaching of Modelling and Applications, Cape Town, South Africa.

Document status and date:

Published: 01/01/2017

Document Version:

Peer reviewed version

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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From Royaumont to Lyon: Applications and Modelling During the Sixties

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Abstract At the Royaumont Seminar (1959) the *New Math* reform was officially launched. In the decade between Royaumont and the first ICME congress in Lyon (1969), many mathematics educators were involved in actions to facilitate the implementation of the *New Math* reform in their country. The *New Math* advocates were convinced that a deep knowledge and understanding of the structures of modern mathematics was a prerequisite to arrive at substantial applications, but in actual classroom practices the applied side of mathematics was often completely neglected. But already at the Royaumont Seminar there were alternative voices who pleaded for taking the role of applications seriously. We investigate the arguments for integrating applications in mathematics education, as well as the kind of (new) applications that were envisaged, at the Royaumont Seminar and in the decade thereafter, a period which is still less well documented in the history of our field.

1 Introduction

The OEEC Seminar, held from November 23 to December 5, 1959 at the *Cercle Culturel de Royaumont* in Asnières-sur-Oise (France) is considered as a turning point in the history of mathematics education in Europe and in the United States (De Bock & Vanpaemel 2015). As Bjarnadóttir (2008, p. 145) stated: “The Royaumont Seminar can be seen as the beginning of a common reform movement to modernize school mathematics in the world”. Or in the words of Skovsmose (2009, p. 332): “After the Royaumont seminar, modern mathematics education spread worldwide, and dominated a variety of curriculum reforms”. The famous slogan “Euclid must go!”, launched at Royaumont by the *Bourbakist* Jean Dieudonné, became a symbol of the radical modernization of school mathematics. Most of the Royaumont proposals were strongly influenced by *Bourbaki*, the French structuralist school whose members or adherents, such as Gustave Choquet, Jean Dieudonné, Lucienne Félix and Willy Servais, were well represented at the Seminar. According to these scholars, the basic model for modernizing school mathematics should be the academic discipline of mathematics, as re-constructed and formalized from the late 1930s on by *Bourbaki*. Recent archival research by Schubring (2013) revealed clear-cut evidence for a close connection between the organisers of the Seminar and the entire *Bourbaki* group.

Less well known is that also alternative reform proposals, emphasizing the role of applications in school mathematics, were voiced at Royaumont. This was also inspired by the developments in the field of applications during WW2. These proposals were however less decisive for developments during the 1960s than the dominant structuralist ideas. These ideas, especially what should be taught about the (axiomatic) basis of mathematics in school determined the debate. In this chapter, we first discuss the kind of (new) applications that were envisaged by some Royaumont lecturers, as well as their pleas for integrating the

42 applied side of mathematics in secondary school curricula. This discussion will be based on
43 *New Thinking in School Mathematics* (OEEC 1961a), the official report of the Royaumont
44 Seminar. Second, we examine the views of the more radical *New Math* reformers on
45 applications or more generally, on the usefulness of mathematics. Third, we follow the
46 debate on applications and modelling in the mathematics education community between
47 Royaumont and the first ICME congress in Lyon (August 24 - 31, 1969). For several
48 reasons, this decade is less well documented in the history of our field. At that time,
49 *L'Enseignement Mathématique*, the only international journal on mathematics education
50 until the late 1960s, had become a purely mathematical journal (see Furinghetti 2009) and
51 the international conference series which are now strongly established in our field (ICME,
52 PME, ICTMA, HPM, ...) had not yet started. An exception might be the annual meetings
53 of the *International Commission for the Study and Improvement of Mathematics Teaching*
54 (CIEAEM), founded in the early 1950s, but CIEAEM only started publishing *Proceedings*
55 of their meetings in 1974 (Bernet and Jaquet 1998).

56 Although there were no strong international communication channels in the mathematics
57 education community during the early- and mid-1960s, it was a very rich period of
58 noteworthy international activity, including several seminars and symposia organised under
59 the auspices of OEEC/OECD, UNESCO or ICMI (see, e.g., Furinghetti et al. 1998). These
60 meetings mainly focused on issues related to the forthcoming introduction of *New Math*
61 (program development, renewal of geometry teaching, teacher (re-)education and new
62 didactical methods), but occasionally, concerns and proposals about the integration of
63 applications in the curricula were expressed too. On the basis of the *Proceedings* and other
64 edited documents from these meetings, we more generally review the visions at that time
65 on the role of applications in mathematics education at the international forum.

66 By the end of the 1960s the debate on applications and modelling gained momentum.
67 Hans Freudenthal, at that time president-elect of ICMI, organized the international
68 colloquium "How to Teach Mathematics so as to Be Useful" (Utrecht, August 21-25,
69 1967). The contributions to that colloquium were published in the first issue of *Educational*
70 *Studies in Mathematics* (May, 1968). In his introductory address, Freudenthal took the
71 opportunity to explain his views on the colloquium's theme. He argued that students could
72 not be expected to (be able to) apply the mathematics they had been taught in a purely
73 theoretical way. Instead, for enabling students to apply the mathematics they have learned,
74 mathematics education should start from concrete contexts and patiently return to these
75 contexts as often as needed (Freudenthal 1968). It is the beginning of a new era in which
76 applications and modelling gradually became an essential part of mathematics education. In
77 the Netherlands, the theory and practice of *Realistic Mathematics Education* (RME) were
78 developed and inspired the teaching of mathematics in a large number of countries
79 worldwide (Van den Heuvel-Panhuizen et al. in press). We conclude this chapter with a
80 more detailed discussion of Freudenthal's ideas on applications and modelling in the years
81 preceding ICME-1.

82 Although the focus of this chapter is on what happened in Europe and North America,
83 we are convinced that it is also applicable to most other countries.

84 **2 Applied Mathematics at the Royaumont Seminar**

85 The Royaumont Seminar was organised by the *Office for Scientific and Technical*
86 *Personnel* (OSTP) of the *Organisation for European Economic Cooperation* (OEEC; later
87 joined by nations outside Europe to form the *Organisation for Economic Co-operation and*
88 *Development*, OECD). The *Office* was created for the purpose of promoting international
89 action to increase the supply and improve the quality of scientists and engineers in OEEC
90 countries (OEEC 1961a). The main motive for OEEC/OSTP to organise a Seminar aimed at
91 upgrading mathematics education was clearly economic: industry and other branches of
92 economic activity were confronted with new applications of mathematics leading to a
93 demand for more mathematicians with new kinds of skills. Therefore a re-appraisal of the
94 content and methods of school mathematics was needed. In his opening address, Marshall
95 H. Stone, at that time president-elect of ICMI, formulated the functional argument as
96 follows:

97 [...] the usefulness of mathematics in practical matters has been an added factor in its vitality as a
98 component of the school curriculum. In this period of history it is the rise of modern science and the
99 ensuing creation of a technological society which compels us to give increasing weight to the
100 utilitarian arguments for the more intensive teaching of mathematics (OEEC 1961a, p. 17).

101 Stone also emphasized the need for a better coordination between mathematics and science
102 teaching: “It is not going to be sufficient to improve the mathematical curriculum as an
103 isolated part (...). It is of the first importance that instruction in mathematics and in the
104 various sciences should be adequately co-ordinated” (OEEC 1961a, p. 21).

105 In view of the above, the Royaumont Seminar should thus have been a breakthrough of
106 an applied and interdisciplinary perspective in mathematics education, but it turned out
107 differently. Due to a dominance at the Seminar of professional mathematicians, most of
108 them members or adherents of the French structuralist school, pure academic mathematics
109 was *de facto* adopted as a model for school mathematics and most participants only paid lip
110 service to the active application of mathematics. For instance, Dieudonné admittedly
111 referred to applications to theoretical physics as a main argument for the inclusion of new
112 topics in university courses of analysis, but leaved open the question whether any kind of
113 “applied mathematics” should already be integrated in the secondary school programs.
114 Nevertheless, he believed that a favourable consideration of his reform proposals, having a
115 clear *Bourbaki* orientation, would already provide the theoretical foundations for teaching
116 questions of applied mathematics (OEEC 1961a).

117 An alternative voice at Royaumont was that of Albert W. Tucker, a
118 Canadian mathematician at that time working at Princeton. Tucker discussed the aspect of
119 new uses of mathematics and their implication for mathematics education. Rather than
120 study problems which involve two variables – or at most three or four – as most problems
121 in classical physics, new branches of mathematics are developed to deal with complex
122 realities involving several variables, which often occur in in the social sciences, for instance
123 in economics and psychology. Within these realities, Tucker distinguishes problems of
124 *disorganised complexity* and problems of *organised complexity*. The first category refers to
125 problems with numerous variables and asks for techniques of probability theory and
126 statistical interference, being effective for describing “average behaviour”. Problems of
127 *organised complexity* involve a sizable number of factors which are inter-related into an
128 organic whole and require, among other things, a knowledge and use of matrix algebra.

129 Tucker exemplifies this last category with a problem of linear programming, utilising
130 inequalities, intersections, graphic methods, and unique algebraic procedures for solving
131 equations. According to Tucker, an integration in all secondary-school programs of these
132 newer types of mathematics, in a suitable form, is feasible and desirable. He however
133 acknowledges that an effort is needed to enhance teachers' knowledge about modern
134 mathematics and its applications to teach the subject well (OEEC 1961a).

135 Tucker's plea for the integration of probability theory and statistics in secondary-school
136 curricula was supported by Luke N. H. Bunt from Utrecht University (The Netherlands).
137 Bunt presented at Royaumont the outline of a syllabus on this subject matter taught in a
138 Dutch experiment for the alpha streams of secondary schools (for more details on this
139 experiment, see, e.g., Bunt 1959):

- 140 (a) Some elements of descriptive statistics, such as frequency distributions, histograms, mean,
141 median, and standard deviation.
- 142 (b) "Classical" probability theory, with proofs of some of the elementary theorems.
- 143 (c) Intuitive treatment of binomial probability distributions; application to physics.
- 144 (d) Testing of a hypothesis (Bernoulli type of distribution); null hypothesis; level of significance;
145 sample space; critical region; confidence limits; sign test; rank correlation. Only Type I errors
146 (accepting a false hypothesis) are considered.

147 (OEEC 1961a, p. 91)

148 For Bunt the problem of estimating some characteristics of a population on the basis of the
149 values of these characteristics of a sample should be the dominant objective of course in
150 statistics. Also Bunt's proposal went against the general trend of the Royaumont Seminar
151 because (a) he did not primarily focus on those mathematically gifted students that would
152 become mathematicians or engineers, but on future students in economics, psychology and
153 other social sciences, and (b) his didactical approach was pragmatic rather than
154 mathematically rigorous (see also De Bock and Vanpaemel 2015).

155 **3 New Math reformers' view on applications and modelling**

156 Although at Royaumont and in the decade thereafter, there were several calls for
157 mathematical instruction to take applications of mathematics seriously (Niss et al. 2007),
158 *New Math*, strongly focussing on theoretical academic mathematics, was – at least in
159 continental Europe – the dominant reform paradigm. Originally, the ambitions of the *New*
160 *Math* reformers and practitioners' call for a focus on useful mathematics were not in
161 contradiction, or as he stated by Niss (2008):

162 It is worth noticing that despite the strong theoretical orientation of the *New Math* movement, its
163 founders insisted that one of the points of the reform was to provide an ideal platform for dealing with
164 the application of mathematics to matters extra-mathematical (p. 72).

165 Claims about the omnipresence and increased usability of (modern) mathematics can be
166 found in many contemporary sources. In the *Charte de Chambéry*, a main French reform
167 document prepared by the "Commission Lichnerowicz" and adopted by the *Association des*
168 *Professeurs de Mathématiques de l'Enseignement Public* (APMEP), the broad usability of
169 modern mathematics is emphasized (and used as a main argument for the reform of
170 mathematical teaching at all educational levels).

171 Contemporary mathematics is useful in many fields: theoretical physics of course, but also computer
172 science, operational research, stock management of companies, organization charts of big
173 administrations, planning for major projects, sociology, linguistics, medicine (diagnosing), pharmacy
174 ... (Charte de Chambéry 1968).

175 Georges Papy, the architect of the new mathematical curriculum in Belgium and
176 president of the CIEAEM during the mid-1960s, wrote in the *Préface* of *Mathématique*
177 *Moderne 1* (MM1), the first volume of his pioneering textbook series:

178 The scope of the subjects studied in the first 13 chapters [sets and relations] goes *far beyond the*
179 *framework of mathematics* [emphasis added] and is, in fact, an introduction to rational approaches
180 commonly used in all fields of thought, science and technology (Papy 1963, p. vii).

181 A closer look at the MM's approach reveals that Papy indeed occasionally leaves the pure
182 mathematical path and presents "daily-life" situations to introduce new mathematical
183 concepts and structures, but these situations do not incorporate realistic or authentic
184 problem situations to be solved with mathematical tools. Their only purpose is to facilitate
185 comprehension of an abstract formalized definition of the mathematical concept or structure
186 that is targeted. Moreover, the newly learned mathematics is never (re)invested to analyse
187 and to solve new challenging problems outside mathematics.

188 To better characterize the role of extra-mathematical situations in *New Math* courses of
189 the 1960s, Hilton's (1973) distinction between *illustration* and *application* might be
190 helpful. The point Hilton made is essentially the following. A situation, within or outside
191 mathematics, is an *illustration* of a mathematical theory if and only if that situation clarifies
192 the theory. A situation is an *application* of a mathematical theory if and only if that
193 situation is clarified by the theory. For the high-order mathematical structures of the *New*
194 *Math*, such as groups, fields or vector spaces, no *applications* were available for the early-
195 aged students to whom these structures were taught and thus, these structures only could be
196 *illustrated* with concrete instantiations (e.g. concrete materials or games especially
197 constructed for that purpose). Although *New Math* advocates often referred to the universal
198 applicability of the powerful structures of the modern mathematics in today's science and
199 technology, they were unable to demonstrate this applicability to their students, for them it
200 were just words, no tools for real problem solving, application analysis or modelling.

201 [Mathematical] structures are great and admirable machines, but they can produce, in early
202 mathematics education, only too small things and too small effects. These small things are the naive
203 examples of structures which embellish modern mathematics textbooks and which have been designed
204 especially for students (Rouche 1984, p. 138).

205 **4 Applications and Modelling in the Post-Royaumont Era**

206 Based on a survey of 21 national reports, Kemeny (1964) observed that the main interests
207 of the international mathematics education community in late 1950s/early1960s were one-
208 sidedly directed towards pure mathematics. The debate was focussed on the type of new
209 mathematical subjects that could find a place in secondary school programs, on how the
210 teaching of traditional topics could be improved by the adoption of modern ideas, on the
211 "right" way of teaching geometry, ... With the exception of a widely supported plea for
212 teaching some notions of statistics at the secondary level, relatively little attention was paid
213 to the applied side of mathematics. Also at the international meetings on mathematics
214 education of the 1960s, organised by OEEC/OECD, UNESCO or ICMI, only occasionally

215 ideas for integrating applications of mathematics in secondary school curricula were
216 voiced. In the next paragraphs we briefly discuss three main sources of applications that,
217 aside from statistics, were mentioned at these forums.

218 First, reference was still made to applications of mathematics to classical physics. The
219 *Group of Experts*, that met in Dubrovnik (1960) for the purpose of preparing a detailed
220 synopsis for modern secondary school mathematics, as stipulated in one of the Royaumont
221 resolutions (OEEC 1961a), re-insisted on the need for a better coordination between the
222 teaching of mathematics and the teaching of science (particularly of physics), but provided
223 little or no concrete suggestions to put that coordination into practice. An exception might
224 be the early introduction of vectors and the systematic development of their algebraic and
225 geometrical properties in a modern curriculum for school geometry, which they considered,
226 at least potentially, of the greatest use to the students and teachers of physics (OEEC
227 1961b). From physical scientists, an increasing pressure was felt to teach a more or less
228 intuitive introduction to calculus in secondary schools – which was not the case in many
229 countries – but mathematics education reformers of that time did not have clear ideas how
230 such introduction could be properly integrated in a modern mathematical curriculum
231 (Kemeny 1964).

232 Second, there is the mathematics related to the upcoming computing machines which
233 began to fundamentally impact secondary school mathematics. Examples of new computer-
234 related applications and their curricular impact were thoroughly discussed at the OECD
235 conference in Athens (1963). That conference provided a special section on “applications in
236 the modernisation of mathematics” (OECD 1964) in which Henry O. Pollak (USA), one of
237 the pioneers in the field of applications and modelling in mathematics education, examined,
238 among other things, new areas of mathematics motivated by computer sciences. He stated
239 that the basic notions of programming, including the use of flow diagrams in the
240 construction of algorithms, should be essential parts of secondary school curricula. But as
241 Hermann Athen, a German contributor to that Athens conference argued, computers may
242 have a much broader impact:

243 A factor not to be neglected is the technical and economic revolution which is taking place as a
244 consequence of the big automatic computers. This revolution in psychic and intellectual functions of
245 human thinking and computing is continuously leading to new investigations in the fields of logic and
246 the analysis of thinking. There is practically no field of mathematical investigation which is not
247 dependent upon the use of computers, e.g. many problems of the social, behavioural, managerial and
248 economic sciences (OECD 1964, p. 245).

249 Other topics, in some way or another related to computers or their use, were suggested at
250 that time, for instance binary representations of numbers, coding, numerical analysis,
251 discrete mathematics, electrical circuits, logic and Boolean algebra.

252 Third, as a genuine application to economics and other social sciences, linear
253 programming was repeatedly mentioned. The topic fitted well within a modern course of
254 linear algebra, but also could strengthen students’ numerical skills related to solving
255 equations and inequalities. Moreover, it opened a window to operational research, a recent
256 field of applied mathematics that deals with the application of advanced analytical methods
257 to help make better decisions given certain constraints. Probably more than other fields of
258 application, optimization involves mathematizing and modelling, i.e. interpreting a real-

259 world situation in terms of a precisely formulated mathematical model (OECD 1964).
260 Modelling and models were not yet widespread notions during the 1960s, but they gained
261 ground. In his *Introduction* to the *Proceedings* of the UNESCO colloquium in Bucharest
262 (1968), Nicolae Teodorescu observed that the notion of *model* had acquired universal
263 presence and circulation, and already acknowledged the cyclic nature of modelling
264 processes.

265 Modelling the complex, heterogeneous reality is the deliberate aim of any modern research method in
266 sciences of nature, in social sciences and in humanities. The victorious penetration of mathematics in
267 other scientific domains is accounted for by modelling which, repeated successively, leads to
268 mathematical models (International UNESCO Colloquium 1968, p. 27).

269 **5 Freudenthal and the Emerging RME Movement**

270 The end of the 1960s was characterized by an increased interest for the didactics of
271 mathematics, particularly at the micro level. Not only the purely mathematical subjects, but
272 the way a child learns, became a main guiding principle for developing mathematics
273 education. This new trend was reflected in a growing number of (international) congresses
274 and meetings in the field. In the context of this chapter, the ICMI colloquium initiated by
275 Hans Freudenthal around the theme “How to Teach Mathematics so as to Be Useful”
276 (Utrecht, August 21-25, 1967), deserves our special attention. It was the first international
277 meeting in which an international panel discussed the differences in opinion about the role
278 of the use of mathematics (La Bastide-Van Gemert 2015). In his opening address
279 Freudenthal sketched, in a general way, his views on mathematics education. He explained
280 that teaching mathematics “so as to be useful” is not the same as teaching useful
281 mathematics:

282 Useful mathematics may prove useful as long as the context does not change, and not a bit longer, and
283 this is just the contrary of what true mathematics should be. Indeed it is the marvelous power of
284 mathematics to eliminate the context. [...] In an objective sense the most abstract mathematics is
285 without doubt the most flexible. In an objective sense, but not subjectively [...] (Freudenthal 1968, p.
286 5).

287 He further argued that we should neither teach “applied mathematics”, nor “pure
288 mathematics” (and expect that the student will be able to apply it later). Mathematics is
289 rather learned by doing, as a human activity, as a process of mathematizing reality and if
290 possible, even of mathematizing mathematics.

291 The problem is not what kind of mathematics, but how mathematics has to be taught. In its first
292 principles mathematics means mathematizing reality, and for most of its users this is the final aspect
293 of mathematics, too. For a few ones this activity extends to mathematizing mathematics itself
294 (Freudenthal 1968, p. 7).

295 Freudenthal’s colloquium is sometimes regarded as the symbolic beginning of a new era
296 in the history of applications and modelling in mathematics education, the so-called
297 *advocacy phase* (Niss et al. 2007) in which advocates of applications and modelling
298 provided arguments in favor of the serious inclusion of such components in the teaching of
299 mathematics. In several countries (such as, for example, the UK and the US), this phase
300 was quickly followed by a second *development* phase, mainly characterized by the
301 development of new educational materials to put such teaching into practice, sometimes by
302 institutes especially created for that purpose. In the Netherlands, for example, the

303 implementation was driven by the *Institute for the Development of Mathematics Education*
304 (IOWO) – founded in 1971 by Freudenthal, nowadays the *Freudenthal Institute* – which
305 shaped the philosophy and practice of *Realistic Mathematics Education* (RME).

306 When in Lyon (1969) the first International Congress on Mathematics Education
307 (ICME-1) was held, Freudenthal was president of ICMI. During ICME-1 two of the twenty
308 published contributions were about applications and modelling (Editorial Board of
309 Educational Studies in Mathematics 1969; Gispert 2003, p.262)

310 6. Conclusion

311 The *New Math* movement, launched at the Royaumont Seminar, was dominated by
312 academic mathematicians who had a genuine interest in education, but most of them were
313 rather involved in pure than in applied mathematical research. Applications were not their
314 first concern. Moreover they were convinced that a thorough insight in the structures of the
315 *New Math* was a solid and necessary basis for teaching questions of applied mathematics.
316 In daily-school practice *New Math* adherents rather used real-world situations to illustrate
317 than to really apply mathematical structures. During the 1960s calls for taking applications
318 – and later also *mathematical modelling* – seriously grew louder and culminated in
319 Freudenthal’s colloquium “How to Teach Mathematics so as to Be Useful”. This meeting
320 marked the beginning of a new and more favorable period in the history of the teaching of
321 mathematical modelling and applications.

322 In sum, it can be stated that the teaching of applied mathematics was not a primary
323 concern during the early- and mid-1960s. But although most leading reformers of that time
324 focussed on pure mathematics and only paid lip service to the active application of
325 mathematics, some mathematics educators highlighted the role of (new) applications – and
326 later also that of modelling – and regarded it as an essential element in the modernization of
327 mathematics teaching.

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